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THE STIGMATOSCOPY METHOD OF DETERMINING THE BINOCULAR REFRACTIVE STATUS*

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INTRODUCTION

The stigmatoscopy method of determining the binocular refractive status consists of alternately focusing a monocularly seen point source of light by moving the position of the source, or by varying its optical distance with lenses, while the observer has binocular fixation on a central target. When the source is in focus, the point conjugate to the retina will have been established.

The position of best focus, while the eye is unaccommodated, will then be at the far point of the eye. In cases of hyperopia, it is advisable to render the eye myopic by the addition of plus lenses, in order that the far point be at a finite distance in front of the eye. In cases of astigmatism the point source will appear as a line or streak which will still be in best focus when at the far point of each principal meridian. The direction of the streak in these two positions is usually at right angles to each other. The distance between the two foci is the astigmatic interval (or Interval of Sturm) and will correspond to the correction cylinder required. The slant of the streak from the horizontal or vertical will indicate the axis of the astigmatism.

Sir George Airy,[1] about 1825, discovered astigmatism in his left eye by observing the image of a light which appeared elliptical to that eye but circular to the other. He determined the amount of astigmatism

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by measuring the distance at which the light appeared as a streak in one meridian and then the distance at which the light appeared as a streak in the meridian at right angles to the former. This is the basis of the subjective method of refraction known as "stigmatoscopy." Airy's own words are as follows:

> "I observe that the image formed by a bright point (as a distant lamp or star) in my left eye was not circular, as it is in the (right) eye . . . but elliptical, the major axis making an angle of about 35° with the vertical and its higher extremity being inclined to the right . . . (The) appearance indicated that the refraction of the eye was greater in the plane nearly vertical than in that at right angles to it and that consequently it would not be possible to see distinctly by the assistance of lenses with spherical surfaces . . .
>
> "To discover the necessary data, I made a very fine hole with the point of a needle in a blackened card, which I caused to slide on a graduated scale; then strongly illuminating a sheet of paper, and holding the card between it and the eye, I had a lucid point upon which I could make observations with great ease and exactness. Then resting the end of the scale upon the cheek bone, and sliding the card on the scale, I found that the point at the distance of 6″, appeared a very well defined line inclined to the vertical about 35° . . . (and) at the distance of 3½″ it appeared a very well defined line at right angles to the former . . . "

DESCRIPTION OF INSTRUMENT

A modified method of stigmatoscopy was introduced by Ames and Gliddon[2] in 1928 and later incorporated into the ophthalmo-eikonometer (Figures 1, 2 and 3). The instrument provides a forehead rest

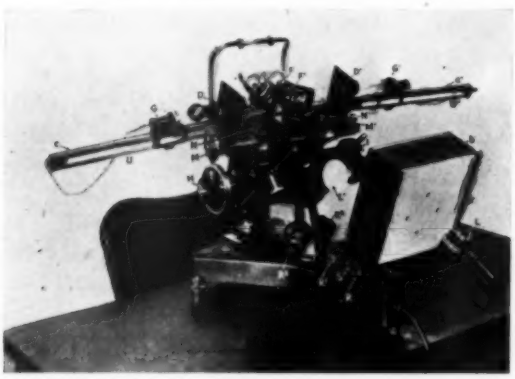


Fig. 1. The ophthalmo-eikonometer.

and chin cup which are mounted on a heavy base and are adjustable so as to align accurately the subject's pupils with the center of the lens cells and to maintain a definite distance (13.75 mm.) between the apex of each cornea and the lenses in the first cells. In front of each eye is placed a semi-reflecting mirror inclined 45° about a vertical axis. These mirrors are partially transparent, so that both eyes can see a target placed

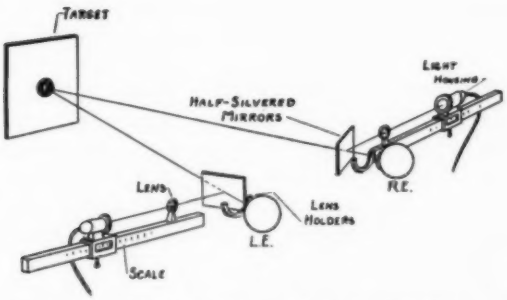


Fig. 2. Drawing of the device, incorporated in the ophthalmo-eikonometer, for measuring the refractive status of the eyes by means of stigmatoscopy.

at 20 feet, or at the reading point. At the same time, by reflection, each eye can see a point source of monochromatic light originating on a side arm at right angles to the line of vision. On these arms are dioptric scales to indicate the optical distance of the light source from the eye. When viewed through the semi-transparent mirrors, the light source appears superimposed on the target in front.

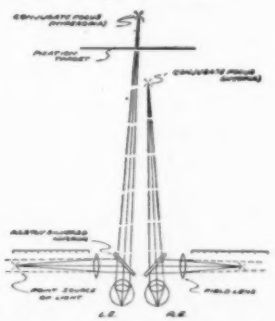


Fig. 3. Schematic diagram of the instrument, showing location of the conjugate foci in myopia (right eye), and hyperopia (left eye).

On the side arms at a distance of 20 cm. from the nodal point of the eyes there are +5.00 D. lenses which serve a double purpose. First, in order to determine the points in space conjugate to the patient's retina, it would be necessary to move the test objects from a point very near the eyes to out beyond infinity. However, for practical reasons it would be impossible to do this. By putting a plus lens between the eyes and the test object the latter can be moved through a relatively short distance to cause a very long range in apparent optical distances. The stronger the plus lens, the less the amount of actual movement neces-

sary for the same amount of apparent optical movement. A lens of +5.00 D. power was chosen as giving a total movement of convenient length.

Second, in determining the dioptric condition while the patient fixates a chart with both eyes, the distance of the test object which appears superimposed on the chart is changed until it appears in sharp focus. Ordinarily, as such a test object is moved nearer, it would increase in size, and decrease when it was moved away. It was found that this change in size tended to cause the patient to alter his dioptric condition. This change of size with change of distance can be prevented by putting a plus lens between the eye and the test object, at a distance from the nodal point of the eye equal to the focal length of the lens. In the instrument it is avoided by putting the +5.00 D. lens used to reduce the necessary movement of test objects at 20 cm. (i.e., its focal length) from the nodal points of the patient's eyes.

On the tracks close to the +5.00 D. lenses are square black aperture screens. The purpose of these aperture screens is to cut off from the patient's eyes the reflections of objects to the right and left of the apparatus which otherwise, due to the 45° mirrors, would appear superimposed on the fixation targets. Lenses may be inserted in cells in front of the subject's eyes to alter the focus as may be required.

It has been found helpful in controlling accommodation to have a fixation object consisting of letters or printed matter. For the fixation distance of 20 ft., a Snellen chart is normally used. In the center of the chart is a black circle about 1 degree in diameter which provides a good background for the focusing of the test object. For the near visual tests at 16 inches, a reading card is provided with a small black central circle upon which the test object is focused.

Various types of test objects are used for measuring different types of ametropia. If the patient has astigmatism, the axis is best determined by means of a row of three small monochromatic point sources of light. For determining the amount of astigmatism the best form of test object is a fine monochromatic line, which is focused first in one principal meridian and then in the other. The difference in the settings in these two meridians indicates the amount of astigmatism which is corrected by inserting appropriate cylindrical lenses from the trial case. For determining the distance of the point conjugate to the retina when there is no astigmatic error, a monochromatic point source is used.

The unique advantage of this method of refraction is that it permits the measurement of the optical condition of each eye while both eyes are fixating binocularly. The refractive condition of the eyes

can be measured at various fixation distances and under various conditions, for instance, the effect on accommodation of changes in convergence induced by prisms can be measured.

Ames and Gliddon[2] found that for the visual distance of 20 feet, the normal setting is about 0.50 to 0.75 diopters on the myopic side for emmetropes or properly corrected ametropes. This may be accounted for by the *spherical aberration*[2, 9, 13] of the eye. The light entering the eye from the periphery of the pupil has considerable effect in focusing the point light source whereas, the central rays have more effect in viewing dark letters on a white background (Figure 4). For near vision, this difference is not found—the focus of the point light source usually corresponds to the fixation distance in non-presbyopic patients since in the accommodated eye the (positive) spherical aberration is markedly reduced or even over-corrected.[8]

In a repeatability study[12] conducted at the Dartmouth Eye Institute on 102 subjects, it was found that the repeatability and therefore, the reliability, was very good as indicated in Table No. 1.

TABLE NO. 1

Repeatability Study of Refraction Determinations by Stigmatoscopy on 102 Subjects

MEAN SETTING OF CONJUGATE POINTS

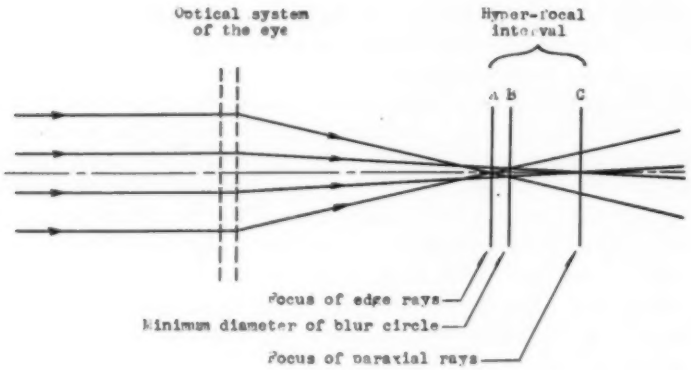
	First Test	Second Test
Distance Vision (20 ft.) - - - - -	+ 0.82 D.	+ 0.81 D.
Near Vision (16 in.) - - - - - -	+ 2.51 D.	+ 2.51 D.

"Repeatability of Ophthalmo-eikonometer Measurements" — Ogle, Imus, Madigan, Bannon & Wilson. Arch. Ophth., 24: 1179, Dec. 1940.

Morgan[11] also found by a similar method of stigmatoscopy using a haploscope arrangement the average settings for distance vision to be 0.50 D. to 0.75 D. myopic. This agrees with the findings of Ames and Gliddon[2] and those of the repeatability studies[12] mentioned above.

The stigmatoscopy method locates with respect to the retina the circle of least confusion of the conoid of spherical aberration. In routine subjective refraction, the practice is to determine the maximum convex or minimum concave lens, combined with the astigmatic correction, which will give best visual acuity. The stigmatoscopy method indicates that this practice results in the smallest diameter of the conoid falling about 0.50 to 0.75 D. in front of the retina.

Luckiesh and Moss[10] found a similar result when they compared their sensitometric technique of refraction with the routine procedures. They stated that the clinical practice of "maximum plus" or "minimum



In measuring refraction by stigmatoscopy, the subject will focus the test point light source so that the retinal image is smallest, i.e.: as shown at B. However, in ordinary seeing, such as viewing dark letters on a white background, the subject usually will prefer a section of the image bundle between B and C. The blur circle will be larger at such a position, but the concentration of light at the center of the blur circle will be greater.

Fig. 4.

minus" was a biased procedure aimed in the direction of plus power. Perhaps some of the empirical formulae for reducing the plus power in final prescriptions would not be needed if the results obtained by the stigmatoscopy or the sensitometric techniques were available on a clinical basis.

What the patient sees during the stigmatoscopy refractive examination is clearly illustrated in Figures 5, 6, and 7. In Figure 5, the best focus of the point source of light is obtained by this observer for his unaccommodated right eye, with fixation at 20 feet, when the setting is 1.42 D. myopic. In order to show the appearance of the image when it is out of focus the point source of light is made further myopic (i.e. brought inside the far point) in 0.50 D. steps and also it is made hyperopic, as shown, by various amounts. It is clear that the subject has no difficulty in choosing, within fairly narrow limits, what is the neatest point focus. Figure 6 represents the character of the images of a point source as seen by this subject's left eye. The best image is when the source is set at 1.20 D. myopic. It is evident that even the best focus is not an exact point. As is well known, but as is here so well demonstrated, the size of the pupil, the various aberrations of the eye and the lack of coincidence in the centering of the ocular media all contribute

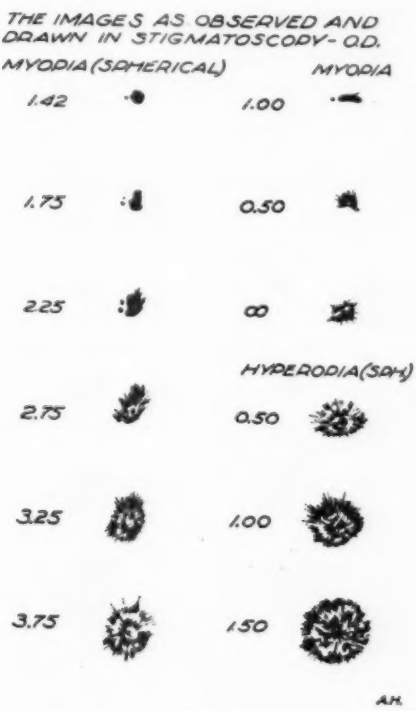


Fig. 5.

to make a perfect point focus impossible. Nevertheless, and this is the important point clinically, the focus that is possible does approximate a point and does permit excellent vision. It is also significant to appreciate how much "out of focus" a half-diopter error can make.

Figure 7 shows the appearance of a point source when astigmatism is present. For the purpose of demonstration, the subject's eye was made astigmatic artificially by inserting in the cell before the eye the following lenses: +1.00 D.C. x90; +1.00 D.C. x180; and, +1.00 D.C. x135. Fixation was at 20 feet and the point source was set at various distances from the eye, as indicated on the figure, and the appearance of the images was drawn as shown.

Figure 8 shows the appearance of the images seen by another subject who has myopia with astigmatism in each eye. Fixation was maintained at 20 feet, and the point source was set at the various dioptric distances indicated. The appearance to each eye (uncorrected) is shown,

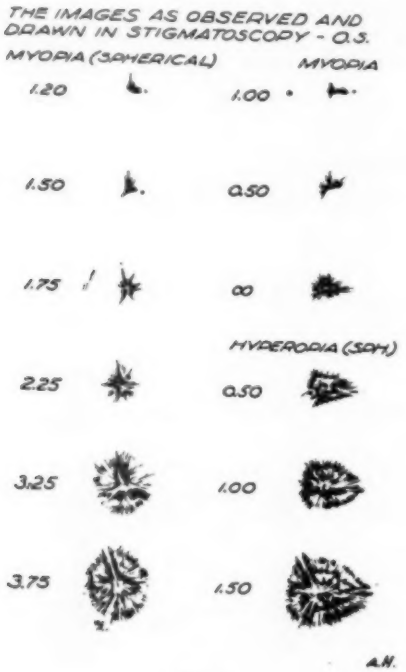


Fig. 6.

and also the appearance to either eye with the indicated correction in the cells before the eye.

DATA

As a basis for further investigations of specific problems in which it is important to know the refractive status of the eyes, it was decided that a group of 100 subjects should be measured by the stigmatoscopy technique for the purpose of ascertaining the accuracy of this method as compared to standard refractive procedures and also for the purpose of familiarizing our staff with the stigmatoscopy technique. The subjects were obtained from the Columbia senior optometry class, the faculty, and other non-presbyopic individuals that were seen as patients in the optometry laboratory.

The refractive settings were obtained for each eye by averaging three to five readings. This average reading differed from individual setting usually in the order of less than 0.25 D.

The spherical and cylindrical refraction was first measured by this

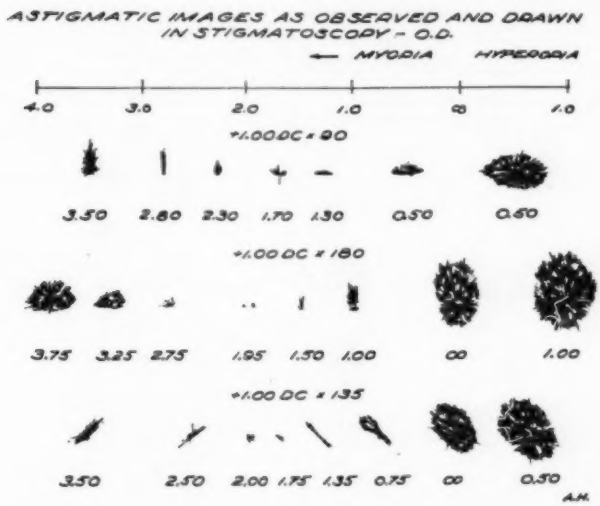


Fig. 7.

method while the patient was looking binocularly in a natural manner at a fixation target consisting of a Snellen chart placed at 20 feet. The indicated correcting lenses were then placed in the cells before the eyes, with an additional amount of plus sphere to make the patient fogged or myopic about 1.00 diopter. Astigmatism was then remeasured and any indicated changes made in the correcting cylinder. Finally, the plus sphere was reduced by 0.25 D. steps and the conjugate focus measured at each step. It was found that a point was reached where further reduction of the plus sphere did not cause the same amount of change in focus, showing that accommodation was then coming into use. The lens correction in the cells at this point was considered to be the static refraction of the eye, as measured by this method, and it was found that the setting for conjugate focus at this point was always on the myopic side, although the visual acuity was not impaired. The average setting for the 100 subjects examined was 0.67 D. for a fixation distance of 20 feet, and 2.40 D. for a fixation distance of 16 inches. *(See Table II)*.

TABLE NO. 2

Refractive Determinations by Stigmatoscopy
on 100 Subjects
Mean Setting of Conjugate Foci

Distance Vision (20 ft.)	+ 0.67 D.
Near Vision (16 in.)	+ 2.40 D.

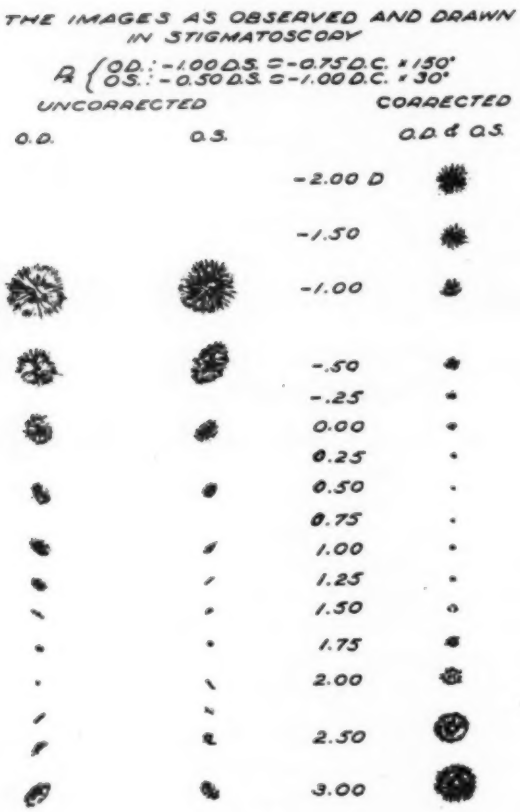
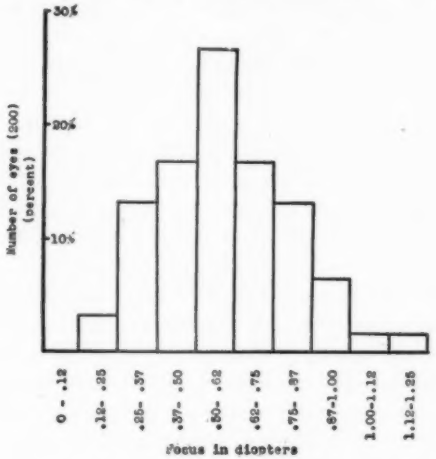


Fig. 8.

The distribution of cases according to setting for conjugate focus (with ametropia corrected) is shown in the accompanying graph (Figure 9). It is seen that the interval from 0.37 D. to 0.75 D. includes 60 per cent of the cases. The average deviation of repeated settings was less than 0.25 D., actually 0.214 D.

The refractive findings by stigmatoscopy and by conventional routine methods have been compared but the tables containing these data are too extensive to reproduce here. The correlation between the two sets of findings is high—differences between the results for the sphere and/or cylinder exceeded 0.25 D. in only four cases, and the findings for axis were identical in most cases.

Therefore, it is obvious that the stigmatoscopy method of refraction is a reliable and accurate means of determining the conjugate foci under the normal conditions of binocular fixation.



Distribution according to setting for conjugate focus, fixation at 20 feet (with ametropia corrected).

Fig. 9.

APPLICATION

The stigmatoscopy method of binocular refraction may be used for several purposes—both clinical and research. While most patients do not require as accurate a balancing of the conjugate foci of each eye as may be determined by stigmatoscopy, nevertheless, there are those "problem cases," in which a very careful and accurate binocular refraction is necessary. The stigmatoscopy method of refraction has been used successfully for many years in conjunction with the tests for aniseikonia. It has been dispensed with on the more recent eikonometers because it was desired to reduce the expense of the instrumentation, the length of the examination time and the amount of office space required.

As a valuable adjunct to routine refractive methods, the stigmatoscopy technique may be used to determine the axis and amount of astigmatism at different fixation distances. In such a study, Bannon[3] found clinically significant differences in the amount and axis of the astigmatism when fixation was changed from 20 feet to 16 inches. Also, the stigmatoscopy method may be used to determine the effect of convergence on accommodation as, for example, in cases of exophoria

where the conjugate foci may be measured under conditions of binocular fixation and compared to the findings when one eye is occluded. Furthermore, prisms correcting the exophoria may be inserted to determine the effect on the accommodation. Such data are useful in deciding whether or not to prescribe prisms and, if so, how much.

In studies of the accommodative-convergence relationships the method of stigmatoscopy is most useful as shown by the research of Ames and Gliddon,[2] Fry,[4,5] Hofstetter,[6,7] and Morgan.[11]

The method of stigmatoscopy also offers unique possibilities for studying the accommodative behavior of the eyes while functional ocular tests are being made. To explore this possibility a normal subject was selected (male, age 23, with no refractive error, normal muscle balance, and normal visual acuity). The positive and negative relative ranges of accommodation were measured in the usual way by adding plus and minus spherical lenses binocularly before the eyes in 0.25D steps. At each lens value stigmatoscopy readings were taken for each eye. When the point of blur-out was reached binocularly, one eye was occluded and the procedure was continued to the point of monocular blur-out. From the data so obtained the amount of accommodation in use at each step

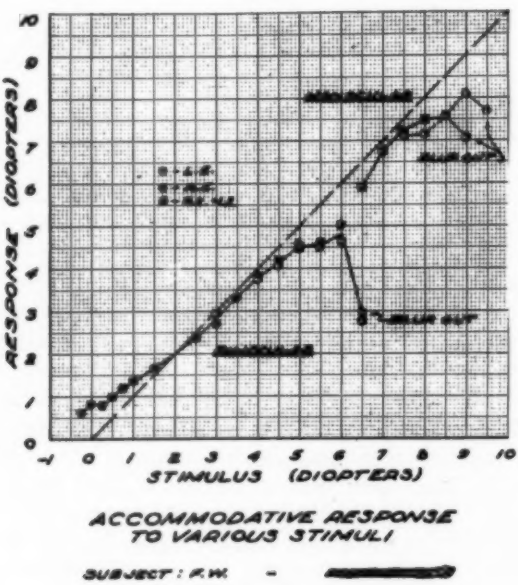


Fig. 10.

was computed. The graph in Figure 10 shows the amount of accommodation in use plotted against the amount of accommodation required for clear focus of fine print at a distance of 40 cm. through each of the spherical lenses placed before the eyes. If sufficient accommodation were exerted to keep the fixation plane in perfect focus the curve would follow (or parallel) the diagonal line. The deviation of the curve from this diagonal line shows the degree of focal error. It is significant to note that the image is out of focus by over a full diopter before the subject reports blur-out. It is also interesting to note that the behavior of the two eyes is almost identical throughout the range of the *binocular* test, although the behavior of the left eye differs significantly from that of the right in the *monocular* phase of the experiment. As would be expected, the subject was able to exert considerably more accommodation monocularly than binocularly before a blur occurred.

Other investigations in which the stigmatoscopy method of binocular refraction may be used include the determination of the influence upon the refractive status of the eyes when viewing various targets used in orthoptic or vision training procedures. For example, what is the correlation between an actual change in focus and the sensation of a change in focus when viewing the "Plateau Spiral," Brock's stereoscopic rings or other stereoscopic targets? Likewise, it would be interesting to determine the influence upon the conjugate foci of viewing flat pictures which give the impression of depth and distance as, for example, perspective drawings, photographs, motion pictures and television. The problem[14, 15] of "nocturnal myopia" or the influence of illumination upon the refractive states of the eye can be investigated by the stigmatoscopy method. Also the far-point of myopic patients who have had vision training can be determined simultaneously with visual acuity readings.

The authors are indebted to Albert Hickey, a senior student in optometry, for the drawings and diagrams.

REFERENCES

[1]Airy, George B.: On a Peculiar Defect in an Eye, and a Mode of Correcting It. Trans. Cambridge Philos. Soc., 1827, Vol. II, p. 267.
[2]Ames, A. and G. H. Gliddon: Ocular Measurements. Trans. Sect. of Ophth. of the A. M. A., 1-68, June 15, 1928.
[3]Bannon, Robert E.: A Study of Astigmatism at the Near Point With Special Reference to Astigmatic Accommodation. Am. J. Optom. & Arch. Am. Acad. Optom., Feb., 1946.
[4]Fry, Glenn A.: An Analysis of the Relationship Between Phoria, Blur, Break and Recovery Findings at the Near Point. Am. J. Optom. & Arch. Am. Acad. Optom., 18(9), 393-402, Sept. 1941.
[5]Fry, Glenn A.: Fundamental Variables in the Relation Between Accommodation & Convergence. Optom. Wkly., 34 (6 & 7), 153-155, 183-185, 1943.
[6]Hofstetter, H. W.: The Proximal Factor in Accommodation & Convergence. Am. J. Optom. & Arch. Am. Acad. Optom., 19(2), 67-76, Feb. 1942.

[7]Hofstetter, H. W.: A Haploscopic Investigation of the Relationship Between Accommodation & Convergence. Abstracts of Doctoral Dissertations, No. 40, The Ohio State Univ. Press, 1943.
[8]Ivanoff, A.: On The Influence of Accommodation on Spherical Aberration in the Human Eye. J. Opt. Soc. Am., 37(9), 730, Sept., 1947.
[9]Lancaster, Walter B.: Stigmatoscopy. Trans. Am. Ophth. Soc., 32:120, 1934.
[10]Luckiesh, M. and F. K. Moss: Comparison of a New Sensitometric Method with Usual Techniques of Refraction. Arch. Ophth., 30: 489-493, 1943.
[11]Morgan, M. W.: The Clinical Aspects of Accommodation & Convergence. Am. J. Optom. & Arch. Am. Acad. Optom., 21(8), 301-313, Aug. 1944.
[12]Ogle, K. N., H. A. Imus, L. F. Madigan, R. E. Bannon, and E. C. Wilson. Repeatability of Ophthalmo-eikonometer Measurements. Arch. Ophth., 24: 1179-1189, Dec., 1940.
[13]Ogle, Kenneth N.: Notes on the Stigmatoscopy Method of Refraction. Dartmouth Eye Institute, March, 1947.
[14]Schoen, Z. J. B.: Objective and Subjective Measures of Night Myopia. Am. J. Optom. & Arch. Am. Acad. Optom., 27(2), 88-94, Feb., 1950.
[15]Wald, George and Donald Griffin: The Changes in Refractive Power of the Human Eye in Dim and Bright Light. J. Opt. Soc. Am., 37(5), 321-336, May, 1947.

ABSTRACTS

THE QUALITY OF MEDICAL CARE IN A NATIONAL HEALTH PROGRAM. Subcommittee on Medical Care. American Public Health Association. American Journal of Public Health. 39:898-924. July, 1949.

This report was prepared as a contribution to the current discussions of national health programs. The principles set forth are considered to be applicable to all types of organized medical care programs, including voluntary and public plans at the local, regional, state or national level. The subcommittee which drew up this report consisted of 15 persons: 11 medical doctors, one dentist, one nurse and two persons whose professions are not indicated. The report is very broad in scope and is concerned with the education of the health professions as well as the details of a national health program. Optometrists will be very much interested in these statements: "Utilization of other professional health workers under competent medical supervision is essential to service of high quality. The full range of medical care today includes the services of the . . . optometrist . . ." "In-so-far as practicable, non-medical practitioners such as optometrists or podiatrists should not be entitled to payment for services except under medical supervision or upon medical referral."

RICHARD FENTON

WHAT DOES THE SCHOOL PHYSICIAN SEE? R. W. Culbert and H. Jacobziner. American Journal of Public Health. 40:567-574. May, 1950.

For 10 consecutive school days in March, 1949, 144 New York City school physicians recorded their findings for each pupil examined by them during the course of a routine school health session. 14,132 public school children were examined: the average age was nine years; the range four to 15 years. 36.3 per cent were classified as "healthy" while 63.7 per cent had some defect. The various poor health conditions were grouped into 19 categories, one of which was vision. In this category were placed those whose vision was equal to or worse than 20/50 in either eye, whether corrected or not. Ocular pathologies were also included in this group. In number of cases, the vision group ranked fourth. A total of 894 or 6.3 per cent of the pupils examined showed a visual defect. The authors believe their percentage is rather low, probably because their criterion (20/50) was less stringent than other surveys have used. Other surveys show from 12 per cent to 32 per cent visual defectives.

RICHARD FENTON

A COMPARISON OF CLINICAL METHODS OF MEASURING ACCOMMODATIVE-CONVERGENCE*

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Whenever the eyes fixate an object binocularly, the functions of accommodation and convergence act almost simultaneously[1] to bring the image of the object of regard into sharp focus upon each fovea. Neither of these acts are simple reflexes, but on the contrary, they appear to be complex. In order to gain a better understanding of these functions, investigators try to simplify the problem by breaking down these acts into component parts. Considerable care must be exercised when dividing a function into parts, since there are cases in which the sum of the parts differs from the whole. This is particuarly true when the higher cortical levels are involved. In spite of this danger, the practice of considering the parts of a function separately and then reconstructing the whole offers the only method by which an understanding of how a complex function operates. Considerations of a function as a whole generally turn out to be mere descriptions of what happens and not how or why certain events occur.

For example, a radio is a fairly complex electronic device (however, alongside the human nervous system it is an elementary toy). If something goes wrong with a radio set, its function is impaired or destroyed. A radio mechanic in seeking to restore proper function considers the radio set either from the point of view of its physical parts or from the point of view of the separate component circuits. If he uses the first method, he tries out the various parts in turn, in the order which they fail most frequently. If he follows the second method, he checks the various circuits individually to find which one is not operating. A skilled radio technician sometimes seems to operate by inspiration by taking into consideration the radio as a whole. However, he is able to do this because he has a basic understanding of the functioning of the separate parts. Skilled technicians frequently find, however, that intuition does not supply the proper answer and then they, too, must resort to checking the component parts.

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The function of convergence is complex. Maddox[2] in trying to divide this function into its component parts in order to arrive at some understanding of the whole proposed that convergence is made up of the following parts: 1. Tonic convergence; 2. Accommodative - convergence; 3. Psychic nearness convergence; and 4. Fusional convergence.

The major emphasis here will be upon accommodative - convergence but in order to bring out its relationship to the other parts of the whole function of convergence, some consideration must be given to the other components.

Tonic convergence is generally defined as the amount of convergence, either positive or negative, that is stimulated when the subject is actively fixating some distant object with accommodation inhibited and with fusion likewise inhibited. The target must be at six meters or more from the subject so that there is no possibility of convergence being stimulated by the subject being aware that the target is near to him. This requirement rules out the use of the various types of stereoscopes even though distance may be stimulated optically and by the stereogram presented. Accommodation must also be inhibited. Of course, this is a difficult matter to define because the inhibition must be central within the nervous system and not necessarily at the motor effector. The various cycloplegics in common use prevent impulses arriving at the motor end plate of the motor nerve from effecting the muscle. The muscle does not react even though there may be nerve impulses. This means that cycloplegics are not the answer to this problem. For practical purposes one assumes that a good subjective correction ordinarily satisfies this condition. Fusion supplies a very strong innervation to the extra-ocular muscles and so this, too, must be eliminated. These requirements for the measurement of tonic convergence make it synonymous with the 'phoria taken with fixation at six meters. Ordinarily this measurement is recorded as so much exophoria or esophoria or as orthophoria. If we wish to think of this measurement as tonic convergence, exophoria is recorded as minus convergence, esophoria as plus, and orthophoria as zero. For example, 2Δ exophoria is —2Δ of tonic convergence. Tonic convergence fails by 2Δ of bringing the visual lines into the proper position to fixate the object of regard.

Accommodative - convergence is the amount of convergence which is stimulated by accommodation and in order to measure it satisfactorily the other factors must be eliminated. Frequently this value is expressed as a ratio: The amount of accommodative - convergence associated with one unit of accommodation. When this method of recording is used, it is called the ACA ratio or the accommodative- con-

vergence gradient. It will be pointed out later that the term gradient should best be reserved for designating this function when it is measured in a specific manner. There does not seem to be any agreement as to what constitutes the proper clinical measurement of this function.

Psychic nearness convergence is a well known function that is frequently overlooked. Subjects will converge when they know the target is near to their eyes, even though accommodation is inactive and fusion prevented. Most manufacturers of ophthalmic Brewster type stereoscopes take this into account. The slides manufactured by the Keystone View Company, for example, are decentered inward even when they are placed at the zero accommodation position in the telebinocular. The vast majority of the slides make an allowance of 8Δ of convergence. The DB slide used for measuring the phoria position of the eyes is calibrated so that orthophoria is registered when the visual lines converge 8Δ. There does not, however, seem to be any adequate description in the literature of a method for clinically determining whether a subject does converge due to psychic awareness that the target is at a finite distance.

Fusional convergence is more readily defined and much more readily measured than is psychic nearness convergence. When the subject fixates a distant target, the fusional convergence activated is equal to the tonic convergence but opposite in sign. For example, if the subject has 3Δ of esophoria for a 6M fixation distance, his tonic convergence is +3Δ and his fusional convergence is —3Δ. Fusional convergence is the amount by which other factors fail to bring the visual lines into the proper positions so that the right and left visual lines intersect at the point of regard. It should be emphasized that this discussion pertains to the fusional convergence actually used and not to the probable limits of fusional convergence which are determined by the use of base-out and base-in prisms, as in determining adduction and abduction. When the target is near to the subject, fusional convergence is equal to the phoria taken at that distance. Under these circumstances tonic convergence, accommodative - convergence and psychic nearness convergence are all acting simultaneously but fusion is inhibited, generally by the use of vertical prism before the eyes. These three factors bring the visual lines into some position so that they intersect in front of the target, at the target or beyond it. Any discrepancy is then thought to be made up by fusional convergence. For example, if the subject has 5Δ of exophoria when fixating a target at 40 cms., it means that the total of tonic, accommodative, and psychic nearness convergence is 5Δ

short of causing the visual lines to intersect at the point fixated. Under these circumstances fusional convergence will be $+5\Delta$ if single vision results when the dissociating device is removed.

Since both tonic and fusional convergences depend on accurate measurement of a phoria, the measurement of phorias rather than these two functions will be considered. There are two fairly popular methods of taking these measurements: The von Graefe method of using a dissociating vertical prism and the Maddox method using a light and a Maddox rod. There seems to be fair agreement in the literature[3, 4] that these two methods give comparable results, particularly when applied to the phoria for distant fixation. The case is not as clear, however, when the phoria for a near fixation point is being considered. A light is a poor stimulus to accommodation unless the subject is directed to actively fixate and focus on the filament of the lamp or on the edges of the light. The von Graefe method, therefore, seems preferable for phoria measurements for finite distances of fixation in which accommodation becomes active.

The influence of accommodation on the near phoria deserves special emphasis. One of the purposes for taking the near phoria is to get some idea of the required fusional convergence for this distance. Now the tonic, accommodative and psychic nearness factors are all active. If we wish to measure the required fusional convergence, these other factors must be held constant and not allowed to vary during the time of the measurement. If any measurement is worth taking, it must be repeatable. Thus not only must these other factors be held constant during any one testing period, they must be readily reestablished at the same level of activity at any subsequent testing period. The conditions for detecting changes in tonic convergence can be restored by fixating a distant target, inhibiting accommodation by the proper lens correction and inhibiting fusion. The accommodative effort can be restored by using the proper lens correction and placing the fixation target at the same distance from the eyes, providing the subject actively fixates and accurately focuses upon the target. If the subject lets his attention wander and looks at first one target and then the other as the spirit moves him, accommodation will vary and the examiner has no way to detect these variations except that the resultant phoria will lack stability. The patient must be instructed to look at only one of the diplopic targets. He must be told to focus upon this target and to keep it clear and distinct at all times. If it blurs, he is to report this fact to the examiner. As one who teaches, the writer is impressed by the complexity of making a phoria measurement at near distances rather than by its simplicity.

Again, accommodation must not be allowed to vary during this test and it must represent as accurately as possible the dioptric value of the fixation distance so that the amount of accommodation in force will be known.

There are several methods by which it has been proposed that accommodative-convergence can be measured. Not one of these methods is more generally accepted than any other. Four of the principal ones are:

1. The gradient method.
2. The phoria method.
3. The cross cylinder / phoria method.
4. The relative accommodations / phoria method.

The gradient method is the simplest and gives directly the ACA ratio. Immediately after the phoria for near fixation a second phoria through a +1.00 D.S., or a —1.00 D.S. add is taken. The difference in the convergence thus measured gives the amount by which a unit change in accommodation affects convergence. For example, if the phoria through the subjective with fixation at 40 cms., is 3Δ exophoria and the phoria through a +1.00 D.S. add over the subjective is 6Δ exophoria, then the ACA ratio is —3Δ/+1.00 D. or simply 3Δ/1.00 D. The advantages of this method are its extreme simplicity and the fact that psychic nearness convergence is eliminated since it probably is constant for both measurements and thus disappears in the subtraction. Its disadvantage is that the change is small and an error in measurement will represent a rather large proportion of the whole measurement. The average value lies between 3.5Δ to 4.0Δ of convergence for each diopter of accommodation[5, 6]. The total amount of accommodative-convergence is then the amount of accommodation in force times the ACA as found by the gradient. Thus for 40 cm. fixation distance:

$$\text{Accommodative Convergence} = 2.5 \times \text{gradient.}$$

One of the oldest methods of determining the amount of accommodative-convergence is by finding how much tonic convergence is present. Then the fusional convergence for the near fixation is determined. Both of these amounts are then subtracted from the total convergence necessary to fixate the point. This is expressed by the formula:

$$A - C = \text{Conv} - (\text{Tonic Conv} + \text{Fusional Conv})$$

For example. Patient has an interpupillary distance of 60 mm. and fixates a target at 40 cms. If the phoria at distance is 1Δ exophoria and that at 40 cms. is 5Δ exophoria, then tonic convergence is —1Δ and fusional convergence is +5Δ.

$$A - C = 15 - (-1 + 5) = 15 - 4$$
$$A - C = 11\Delta$$

This method entirely overlooks psychic nearness convergence. In fact this measurement includes both psychic and accommodative convergence and hence fails to determine accommodative-convergence.

Perhaps the most used method of measuring accommodative-convergence is by the cross cylinder / phoria measurement. Both the monocular (dissociated) cross cylinder and the binocular cross cylinder findings are used. Since the same comments apply to both, only the monocular cross cylinder / phoria finding will be discussed. Obviously if the add of the cross cylinder and the change in phoria is used, the finding is exactly the same as the gradient. However, this is not the general method of application. Usually one of the most mechanistic concepts in optometry is employed. The total finding of the cross cylinder and the full amount of the phoria is compared to the supposed normal of 6Δ of convergence for each diopter of accommodation. This method of application immediately assumes that everyone has the identical relationship between these two functions. Frequently the cross cylinders are not removed when the phoria is measured. With these lenses in place, it is obviously impossible for the patient to accommodate accurately due to the artificial astigmatism created by these lenses. If the total phoria is used and not the change in phoria, there has been no attempt to take either tonic convergence or fusional convergence into account. Under these circumstances the test cannot be used to measure accommodative-convergence. If, as mentioned above, the change in phoria caused by the add is used, the test is equally as good as the gradient, providing a target demanding accurate focus is used and the cross cylinders are removed during the phoria determination.

The fallacy of using the total amount of the cross cylinder and the total phoria through this finding can be shown from the following example: Assume the following data to have been found:

Subjective: O. U. plano.
Phoria at 6M: 2Δ Exophoria.
Phoria at 40 cms: 10Δ Exophoria.
Monocular cross cylinder: +1.00 D.S.
Phoria through cross cylinder: 12Δ Exophoria.
Base-out prism to blur: 6Δ.

If the total phoria and cross cylinder data are used to determine the so-called "lag," we have

$$\frac{12}{15} = \frac{x}{2.50} \quad : \quad x = 2.00$$

When this is deducted from the total lens power of the cross cylinder, we find

$$+1.00 - 2.00 = -1.00 \text{ D.S.}$$

Thus according to this technique, the patient is a "minus projector" on the path to becoming myopic since concave lenses are supposed to be indicated for near use. The ratio of the phoria change to add is

$$-2\Delta \ / \ +1.00 \text{ D.}$$

These patients are nearly always given visual training for "plus acceptance." Suppose the following data are found at a subsequent date after training:

Subjective: O. U. +0.25 D.S.
Phoria at 6M: Orthophoria.
Phoria at 40 cms: 8Δ Exophoria.
Monocular cross cylinder: +2.75 D.S.
Phoria through cross cylinder: 13Δ Exophoria.
Base-out to blur at 40 cms: 20Δ.

Using total values again, the relationship is, by the "lag" formula

$$\frac{13}{15} = \frac{x}{2.5} \qquad x = 2.12 \text{ D.}$$

The "near net" is then

$$+ 2.75 - 2.12 = +0.62 \text{ D.S.}$$

The patient is now said to accept plus.

Now the question arises as to whether there has been any basic change in the ACA ratio. This can be determined by again examining the ratio of the changes in phoria with the add. The add of the cross cylinder is +2.50 D.S. and the change in phoria is from 8Δ exophoria to 13Δ exophoria or 5Δ.

$$-5\Delta \ / \ +2.50 \text{ D.} = -2\Delta \ / \ +1.00 \text{ D.S.}$$

Thus there has been no basic change in the ACA ratio. What has occurred as a result of training is that the base-out to blur finding has been increased, which will improve, beyond question, the "plus acceptance." The argument is not about what is accomplished but how and why it is accomplished.

This method of using the cross cylinder data does not actually measure the accommodative-convergence. The amount of this function is assumed and everyone is supposed to have an ACA ratio of 6Δ/1.00 D. There is no evidence that the "near net" determined actually represents an exact correction. On the whole the correction arrived at is fairly satisfactory for the average subject because two errors are made which tend, on the average, to cancel each other. The normal ACA is much nearer to 4/1.00 than it is 6/1.00. However, since the total

phoria is used and not the change in phoria, the initial phoria is included. Now the initial phoria, on the average, is about 5Δ exophoria when fixation is at 40 cms. and therefore 2.50 D. of accommodation is active. When this is erroneously included as a ratio, it adds about 2Δ/1.00 D. to the original 4Δ/1.00 D., thus making the total 6Δ/1.00 D. Actually, however, the 2.50 D. of accommodation is not associated with a change in convergence of 5Δ but with a change in convergence of from zero at infinity to 15—5 or 10Δ at 40 cms. or again 4Δ/1.00 D.

The last method of determining the accommodative-convergence is by using the plus or minus lens add to blur the phoria through this lens power. The fact that the target is blurred to the subject makes this method poor. If the target is blurred, the focus of the eye has not changed in step with the added lens power. This means that the amount of accommodation in force cannot be determined and that it is certainly not that represented by fixation distance plus the lenses added. Consequently the measurement is useless as a determination of accommodative-convergence.

It would thus appear that the only reliable method for determining the accommodative-convergence is the gradient method. The only other method which gives reliable information is the phoria method. This determination includes psychic nearness convergence in addition to accommodative-convergence. In order to determine whether a comparison of these two methods could be used to determine psychic nearness convergence, it was decided to compare the accommodative-convergence data by both methods. The data of the clinical instructors of the school of optometry of the University of California for the first two months of the spring semester of 1949 were examined to determine the accommodative-convergence by both the gradient and the phoria method.

The gradient determination is routinely made as a part of the normal clinical examination. Thus in order to find the accommodative-convergence by the gradient method, this finding on the record card was simply multiplied by 2.5 which represents the accommodation in force at 40 cms. Generally speaking the accommodation will be somewhat less than 2.5, but since a comparison is to be made with data taken on the same patient at the same time, it can safely be assumed that some constant level of accommodation was maintained by the patient. In the subsequent subtraction this factor is eliminated:

$$(A\text{-}B) - (D\text{-}B) = x = A - D$$

The determination of the accommodative-convergence by the phoria method was made by determining the necessary convergence for single vision at 40 cms. from each subject's interpupillary distance. The neces-

sary substitutions were then made in the formula given below:

$$A - C = Conv - (Tonic + Fusional)$$

There were 413 subjects refracted by ten clinical instructors during this period. All the patients included in these determinations had more than 5.00 D. of accommodation and had normal binocular vision. Of these 413, there were three with a zero ACA and none with less than zero.

The mean value for the two methods was calculated as was the coefficient of correlation of the two functions, the standard error, and the line of regression. The calculations are shown in Figure 1.

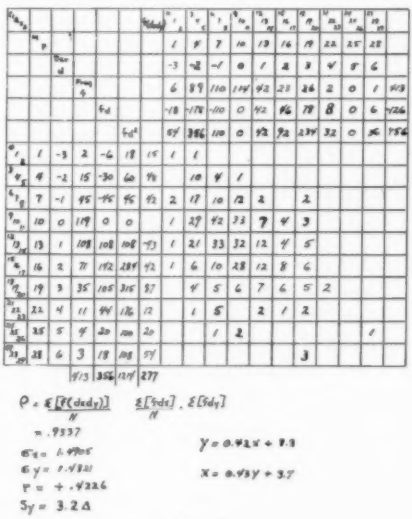

Fig. 1.

The mean value for accommodative-convergence by the gradient method was found to be 9.1Δ and by the phoria method, 12.6Δ. Thus the mean value by the phoria method is larger, as expected, since it is made up of the two functions: psychic convergence and accommodative-convergence.

The coefficient of correlation of the two measurements is +0.423. This indicates that they are related significantly and that as one is high the other will be high also. However, this coefficient also indicates that there is a strong probability that the two measurements actually measure different but related functions. If the same function were being measured by two different types of tests, the correlation between the two should be much higher.

Even more interesting than the coefficient of correlation are the lines of regression which are plotted in Figure 2. The formulas for these two lines are:

$$x = .43y + 3.7$$
$$y = .42x + 8.8$$

Where y = accommodative-convergence by phoria method
x = accommodative-convergence by gradient method.

The second expression above is of greater interest because it appears that the gradient measures the accommodative-convergence directly, while the phoria method includes both accommodative-convergence and psychic nearness convergence. Since accommodative-convergence is com-

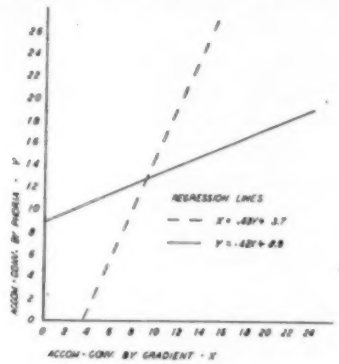

Fig. 2.

mon to both, if the measurement by the gradient method is subtracted from the measurement by the phoria method the answer should give the psychic nearness convergence. The results of this subtraction are shown in Figure 3. Along the abscissa are various values for accommodative-convergence by the gradient while along the ordinate are values for the difference between the two methods. The three points shown by x's were calculated by the regression line formula $y = .42x + 8.8$. The O's were determined by calculating the mean value of each vertical column in Figure 1. From this mean, the mid value of the gradient accommodative-convergence was subtracted and the results plotted. The very small scatter on either side of the regression line would seem to indicate that this function is represented satisfactorily by a straight line given by the regression formula.

Inspection of the data given in Figure 1 reveals that the gradient accommodative-convergence does not follow normal distribution accurately. It also indicates that the last point on the line in Figure 3 represents only two subjects.

It should also be pointed out that this discussion is about averages. Any particular individual may or may not give "normal" or "expected" data. These functions must be determined for the individual and cannot be assumed.

If the line of Figure 3 is inspected it will be noticed that when the accommodative-convergence is small the psychic nearness convergence is large, as we would expect. As accommodative-convergence increases in value and supplies more and more of the total necessary convergence, psychic nearness convergence decreases until it finally reaches 0.0 at the point where accommodative-convergence is just slightly in excess of 15Δ. The average convergence for the 413 subjects based on their interpupillary distance was 16Δ. This negative relationship of accommodative-convergence and psychic convergence has also been reported by Hof-

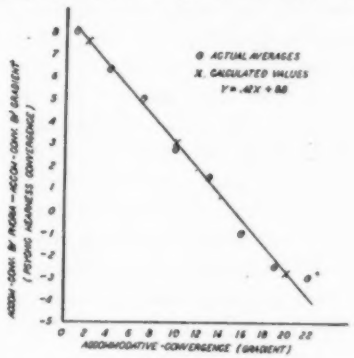
O ACTUAL AVERAGES
X CALCULATED VALUES
ACCOM CONV BY PRISM + RECIP CONV BY GRADIENT
(PSYCHIC NEARNESS CONVERGENCE)
ACCOMMODATIVE CONVERGENCE (GRADIENT)

Fig. 3.

stetter[7] for haploscopic data. Beyond this point, psychic nearness convergence may actually assume a negative value. This would indicate that some subjects might actually tend to stimulate divergence as a target is brought to a near position. This divergent movement is a result of a psychic stimulus since it must be remembered that these measurements were made with the eyes dissociated so that fusion was prevented. This movement of course is only relative and not an actual divergent movement. Its meaning can best be pointed out by an example. Suppose a subject has a 60 mm. interpupillary distance, orthophoria for distance and an accommodative-convergence of 20Δ. One might expect, therefore that the phoria at 40 cms. would be 5Δ esophoria (15Δ required convergence and 20Δ actually supplied by accommodative-convergence). However, for 20Δ of accommodative-convergence, psychic nearness convergence is —3Δ on the average. This means that instead of 5Δ esophoria only 2Δ of esophoria would be uncovered.

This raises the question as to the real ultimate source of psychic nearness convergence. It may be an independent function like tonic convergence, fusional convergence and accommodative-convergence. If this were the case, there should be more scatter and also the probability of finding a negative value would be very small. It is extremely difficult to imagine that a near object should be associated with a relative divergence of the visual lines. Another possibility is that it is a learned function and really is a part of fusional convergence which is stimulated whether fusion is possible or not. When accommodative-convergence is low and if single vision is to be obtained, positive fusional convergence must always be stimulated. Thus a near target is always associated with a positive fusional movement. In time this could become a conditioned reflex so that positive fusional convergence is stimulated just by the nearness of the target. If accommodative-convergence supplies just the right amount of convergence, fusional convergence will not have to be stimulated at all and this association between nearness and positive convergence would not occur and the conditioned reflex would not be established. On the other hand, if accommodative-convergence is excessive, a negative fusional movement must always be stimulated in order to obtain single vision. This might very well establish the conditioned reflex of an association between nearness and a relative divergent movement of the visual lines. If this argument is correct it means that psychic nearness convergence is a learned function much like a conditioned reflex and that it is a special manifestation of fusion convergence and not a separate innate reflex or a part of accommodative-convergence as assumed by Maddox.[2]

REFERENCES

[1]Allen, M. J., An Objective High Speed Photographic Technique for Simultaneously Recording Changes in Accommodation and Convergence. Amer. J. Optom. and Arch. Amer. Acad. Optom., 26:279 (July) 1949.
[2]Maddox, E. E., The Clinical Use of Prisms, 2d Edition, John Wright and Co., Bristol, 1893.
[3]Scobee, R. G. and Green, E. H., Tests for Heterophoria: Reliability of Tests, Comparisons Between Tests, and Effect of Changing Testing Conditions. Am. J. Ophth., 30:436 (April) 1947.
[4]Borish, I. M., Clinical Refraction, Professional Press, Chicago, 1949.
[5]Morgan, M. W., Jr., The Clinical Aspects of Accommodation and Convergence. Amer. J. Optom. and Arch. Amer. Acad. Optom., 21:301 (August) 1944.
[6]Emmes, A. B. (to appear shortly in the Journal).
[7]Hofstetter, H. W., Proximal Factor in Accommodation and Convergence, Amer. J. Optom. and Arch. Amer. Acad. Optom., October, 1947.

PRE-ORTHOPTIC CARE OF THE VERY YOUNG SQUINTER*

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It would be most beneficial for effective results if treatment of non-pathologic strabismus and complicating defects were started at the earliest age at which such anomalies become evident. This viewpoint is neither recent nor new. Peckham[1] described a procedure for correcting strabismus of the very young squinter. He used prisms placed with their bases at varying positions, irrespective of type of deviation. Lenses and a variety of occluders were used in conjunction. Because of the variability of prism position, Peckham termed the prisms "irritating prisms." Aside from changes in our understanding of neuro-muscular innervation and physiology, much of this teaching has merit. Wheeler[2] also agrees that in the treatment of amblyopia, the earlier occlusion is started, the quicker will results be obtained.

Chavasse[3] in discussing methods of occlusion, describes one occluder which he favors (the Chavasse occluder). It consists of a circular or oval patch of adhesive (zinc oxide or other type) tape, having in its center a very small piece of cotton wool no larger than an almond. This patch is put right over the eye in firm contact with the skin, where it tends to stay quite secure. Other methods of occlusion mentioned are eye patches, plastic occluders, colorless nail polish and gummed paper on lenses.

Smith[4] describes a complete system of procedures for handling the pre-school, very young squinter, and also discusses clinical methods for preventing incipient changes and for arresting existing defects.

Nevertheless, the prevailing tendency among most optometrists is to wait until the child is old enough to be cooperative. This may be anywhere from four to seven years of age, depending on the child. Such a process of waiting and delay, however, is wasteful, inasmuch as considerable deterioration of the visual functions and perceptual processes can occur in the meantime. The extent of such deterioration depends on the age at which strabismus first becomes manifest. Amblyopia and suppression occurring in the first year of life, either with or without mani-

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fest strabismus, seems to be most intense and deeprooted. It is this type of amblyopia which is referred to as congenital. The suppression areas may have characteristics of scotoma.

In view of this, it is advisable to try to retard progression of visual and perceptual deterioration in its incipiency. It is often possible, also, to arrest abnormalities which are already existing. Therefore, pre-orthoptic care should be instituted as early as possible. Active orthoptics can then be delayed to a more propitious time.

By pre-orthoptic care is meant a system of preventive-corrective steps and procedures, short of actual orthoptic treatment. These are instituted in an effort to help arrest progression of existing anomalies and to prevent further visual deterioration, if such exists. Considering the fact that such treatment is intended for the very young squinter, the task is not an easy one. Perhaps one of the reasons is that all visual tasks are intended to be done at home. The optometrist sees the child only periodically to put on the occluder and to remove. Progress can be determined at intervals, during these periodic visits.

There are two main reasons for not starting active orthoptic treatment of the very young squinter. First, because complete lack of cooperation makes active orthoptics both impractical and impossible: second, limitation and actual paucity of testing and training material for keeping the attention of the very young child. While it is imperative to be fully aware of such limitations, it is also necessary at the same time to be prepared to utilize every means for evaluating and interpreting whatever findings are obtained. In cases of very young children, it is necessary to depend a great deal upon observation and on objective tests. Here results from such tests must of necessity supersede the subjective. This is simply because subjective testing in most instances is an impossibility. Likewise, if remedial steps are contemplated, they may need to be improvised for the particular case.

There is, nevertheless, a routine of clinical tests which can be made. In some instances these tests may have to be cursory and all data based on approximation. In others, actual, fairly reliable findings may be obtained. There is no way of predetermining results. Each case is a separate and distinct entity. However, many of the visual skills tests ordinarily considered essential in older squinters cannot be made when examing the very young squinter.

The tests considered most essential are:

1. Ophthalmoscopy and examination of the eyes in general and of the refractive media. It is imperative to rule out possible fundus pathology and abnormalities of ocular structures in general.

2. Estimation of monocular and binocular motility and comitancy. This is done to exclude possible presence of motor paralysis or paresis.

3. Estimation of visual perception (if possible). By this test we try to determine the child's ability to see and the extent of seeing, qualitative and quantitative perception. It is needless to state here that such tests are most difficult to perform on the very young squinter, due to lack of cooperation. It may be a simple task to have a child follow a moving target when attempting to evaluate motility and comitancy. But to have the child discern and name objects seen on a visual acuity chart is in many instances wasted effort. I have seen noisy and extremely boisterous youngsters shut up like the proverbial clam when asked to name simple familiar objects. Despite all this, an attempt should be made to determine visual perception.

Completely occluding the better eye during the examination offers, in some instances, a clue to the child's seeing ability. Where sight is extremely subnormal, the child is likely to stumble and fuss and try to pull off the occluder. But, if sight is moderate, no such fussing and balking are manifested. While such occlusion does not disclose the child's actual visual acuity, it nevertheless serves as a clue to the approximate capacity for seeing. Some children with extreme visual deterioration learn early to turn their heads to one side because by so doing, they can see better. Peripheral visual perception, unless recognized, can lead to false clinical data. In cases of strabismus, we are interested in the central, not peripheral visual acuity.

4. Estimation of ocular refraction, particularly that of the squinting eye, must be made. Like the other tests, this must be essentially an objective one. Any ophthalmic prescription required can be written from skiascopic shadows. The extent of allowance for the working distance depends primarily upon the type of strabismus. And the type of skiascopy used in such cases may have to be a combination of static-dynamic. It is best performed at 1 meter, because at that distance accommodative action is a negligible factor. It may be necessary in some cases to perform this test while the mother is holding the child in her lap. This, however, should not deter the test from being done. Being a strabismus case, accuracy in prescribing plus lens correction need not be rigorously exact. Approximation is permissible. Full correction, or even over-correction can have no deleterious effect on hyperopic esotropias or myopic exotropias. Myopic esotropes and hyperopic exotropes, although not commonly encountered in the very young, are nevertheless prevalent. In such cases discretion must be exercised when prescribing optical cor-

rection. Over-correction should be avoided. However, in all types of cases, regardless, it is imperative to prescribe cylindrical correction whenever it is indicated by skiascopy. The axes can be obtained from skiascopic findings.

If subjective verification is possible that should be resorted to without fail. But since moods and actions of the very young squinter are often unpredictable, it may be necessary to dispense with that part of the examination and to depend wholly on instrument findings.

Having prescribed the best possible ophthalmic correction, it is advisable to wait about one or two weeks before starting on pre-orthoptic care. Such time is necessary for the child to become adapted to the lenses and for the examiner to evaluate their effectiveness. At the end of the specified time, a program of prevention-correction is started. This step in the treatment program is a highly important one and is one of which those concerned must be made fully aware. At this time also, it is advisable to photograph the child's eyes as part of the record. These pictures should be made both with and without optical correction, and without occluders. It is incredible how quick and easy it is to forget unpleasant situations and how surprised parents can act when shown original photographic proof as evidence of accomplishment, in some instances only a few months after treatment is started.

The most important single phase in the post-refractive care, in the pre-orthoptic handling of the very young squinter, is occlusion. There are many methods for covering the better eye and the duration of such occlusion is also a matter of wide divergence of opinion and methodology. However, occlusion of the better or non-squinting eye and occlusion in general as a remedial adjunct, is not a new concept. It was advised by Buffon[5] in 1734. He tried to explain strabismus and how to treat it by non-surgical means, including corrective lenses and prolonged occlusion of the better eye. Erasmus Darwin (1801), followed up Buffon's investigations in strabismus and made some original contributions including an occluder consisting of gauze stretched on a circle of whalebone. This was placed over the better eye for some hours daily.

In modern ophthalmic literature occlusion is given wide consideration and the usuage of this procedure is receiving serious attention. Marion K. Eakin and Robert S. Eakin[6] reported results in which occlusion was used in the treatment of five cases of amblyopia. The important part of this report is that all the five were of an age level ranging from seven to 11 and that the results were most gratifying in those cases in which occlusion was used in conjunction with optical correction and visual training.

Repeated periods of constant occlusion and remission from occlusion form the basis for the pre-orthoptic care of the very young squinter. The duration of these constant occlusion periods can be varied from one week to a month. In my own experience, longer periods of such occlusion have caused no ill effect. Remission from occlusion can be for periods ranging from one to two weeks. Covering an eye for an hour a day only is time and effort wasted; so is occluding alternatingly the squinting and non-squinting eye as advised by some practitioners. The basis for such a procedure is explained by the desire to prevent further suppression and to arrest formation of a "false macula" when occlusion of the better eye is removed.

It is important, first of all, to differentiate between orthoptic care as such, and pre-orthoptic care. Active orthoptic care has occlusion as one of the adjuncts. Active orthoptic care can be given to squinters and others requiring such treatment at the proper time and under proper control. The main objective of pre-orthoptic care of the very young squinter, however, is prevention of further deterioration until such a time when remediation can be started in an active form. Therefore, a most important adjunct to occlusion during the pre-orthoptic care is forced and intense usage of the affected eye. This can be accomplished by subjecting the squinting eye to perform specific visual tasks while the better eye is occluded. These tasks must be compatible with the child's capacity for understanding and performance. Such tasks as tracing (on tracing books), projection, drawing, stringing beads, coloring, playing with blocks and other kinds of toys requiring concentration, are most useful. Toys and games are available in a variety of assortment to suit all ages and mental levels. Such work must be made daily routine and not merely given in sporadic fashion. By so doing, existing visual anomalies may be greatly ameliorated and a pattern for preventing further deterioration may thus be established. No orthoptic type instruments are required, but it is imperative that whoever supervises these daily exercises take care not to allow head tilting or face turning and to see to it that the child's posture is correct. On the basis of clinical experience, I can state that mere occlusion of the non-squinting eye without subjecting the squinting one to functional usage, is not of much value.

There is another reason for the urgency of making the squinting eye perform visual tasks. By careful detection and diagnosis, postural defects caused by compound muscular deviations may be caught in time. These vicarious postural adjustments are, according to Peter,[7] Bielschowsky,[8] and Scobee[9] escapes from discomfort induced by maladjust-

ment of the vertical muscles. Unless such head tilting and face turning are recognized and eliminated early, they may become habitual and fixed. No squint case can be considered completely corrected if existing postural maladjustment and the factors which produce it are allowed to persist. Coordinate usage of the hand and affected eye and observance that proper postural (proprioceptive) adjustment be maintained during performance, helps to eliminate acquired vicarious adjustment. Hence, it is important that functional performance by the strabismic eye be continued even during periods of remission. During that time, the better eye is occluded only during the treatment period.

In addition to those already mentioned, there are several other methods available for occluding the better eye. The most effective of these is the Chavasse occluder and covering the eye directly with gauze pads and fastening them with adhesive tape. However, few children take kindly to this mode of occlusion. Other effective methods are either an eye patch directly over the eye, or an occlusion disc. There are some which can be attached to the inner curve of the spectacle lens by means of a suction cup. The occluder is so fashioned as to provide complete coverage, thus eliminating light completely. Then there are celluloid discs which fit over the frame. Some prefer using frosted lenses in fit-over or clip-on frames. Diffusion lenses are quite useful in some instances. I find it very helpful to cover the inside curvature of the spectacle lens of the better eye with adhesive tape. It is very nearly as effective as the most stringent procedures mentioned and less objectionable to the patient. It really does not matter very much if light does enter the eye from the side. When the lens is properly covered with tape and the spectacles are properly fitted, the child would have a great deal of difficulty to look anywhere but straight ahead. Some children will try looking over the top of the lenses, or through the side in order to see better. This must be stopped if best results are to be obtained.

Thus, optical correction, prolonged periods of constant occlusion and intensified usage of the affected eye constitute the pre-orthoptic care of the very young squinter. As already explained, functional performance by the affected eye helps to arrest further visual deterioration and in many instances, tends to correct existing abnormalities. During this period care must be exercised in the child's postural habits. Head tilting and face turning can be caused by an ocular muscle defect. Clinically, three types of torticollis are recognized: (a) ocular, (b) neurological and (c) orthopedic.

It is important to check the refractive condition of the eyes about every three months and to determine effectiveness of the treatment per-

iodically, depending on the duration of occlusion. Alteration in existing muscle defects may be induced as a result of this pre-orthoptic care. Needed changes in ophthalmic correction may be manifested in changes in the perceptual functions and in the performance of the extraocular muscles. I have seen monolateral esotropes develop alternating strabismus, which in turn was corrected by a change in the optical correction.

During the period of pre-orthoptic care, it is important for the optometrist to learn as much as possible of the young squinter's visual and perceptual habits and abnormalities. As the child becomes adjusted to surroundings and becomes less reticent and shy, many tests heretofore considered impossible can be performed. Much depends on the optometrist and his understanding of child behavior.

Active orthoptic treatment should be started as soon as the child is ready for it. A child of three is not too young. The procedure, as in all cases, depends on the defect, the patient and other circumstances. Occlusion can be carried over to the active phase of orthoptics, if conditions require it. In many instances where pre-orthoptic care is diligently carried out and sufficient improvement manifested, prolonged and intensive orthoptic treatment may become unnecessary. In such instances treatment for the correction of existing residual abnormalities invariably completes the case.

REFERENCES

[1]Peckham, R. M. "An Optometric Method of Correcting Strabismus for Children Six Months and Upward Without Exercises." Research Bulletin, No. 5, Published by the Optometric Research Institute, Detroit, Mich., August, 1938.
[2]Wheeler, M. C. "The Handling of the Amblyopic Patient," American Journal of Ophthalmology, Vol. 32, Sept., 1949, pp. 1261-1267.
[3]Chavasse, F. B. "Worth's Squint," 7th Ed., P. Blakiston's Sons & Co., Philadelphia, Pa., 1939, p. 437.
[4]Smith, W. "Clinical Orthoptic Procedure," The C. V. Mosby Co., St. Louis, Mo., 1950, Chapt. XVI and appendix.
[5]Buffon, G. L. "Memoires de l'Academie de Sciences, 1734.
[6]Eakin, M. K. & R. S. "The Use of Occlusion in the Treatment of Amblyopia — Five Case Reports." American Journal of Optometry and Archives of American Academy of Optometry, Vol. 26, Sept., 1949, pp. 400-404.
[7]Peter, L. "The Extraocular Muscles," 3rd Ed., 1941, Lea & Febiger, Philadelphia, Pa.
[8]Bielschowsky, A. "Lectures on Motor Anomalies," Dartmouth College Publication, Hanover, N. H., 1940, p. 70.
[9]Scobee, R. G. "The Oculorotary Muscles," The C. V. Mosby Co., St. Louis, Mo., 1947, p. 281.

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SOME PRELIMINARY OBSERVATIONS ON THE TUOHY CORNEAL LENS*

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The writer wishes to present the following observations made during the past six months on the use of the Tuohy corneal lens. We feel that the fluidless corneal contact lens, developed by K. M. Tuohy, of Los Angeles, California, shows several points of superiority over the larger and more conventional fluid type contact lens. It is the writer's opinion that the Tuohy lens presents a more natural appearance in the eye of the patient and offers greater ease of fitting. Furthermore, we have observed that this lens can be worn for a greater length of time, since most patients have a wearing time of eight to 10 hours with no after effects.

The use of this lens is sometimes contra-indicated in cases of extreme astigmia, especially of the lenticular type: in cases involving only minor refractive errors: in exophthalmia and in certain types of pathology. The writer has seen no conical cornea patients as yet, but understands from Tuohy and his associates that the effects of this affliction are often readily corrected by this lens.

We have found the corneal lens to be especially well adapted in cases of aphakia and high hyperopia, as well as in cases of low myopia. Although no extremely high astigmats have been seen in the writer's practice, we have one patient with 5 diopters of with-the-rule corneal astigmatism who has worked out well with the Tuohy lens.

We have observed that the fitting picture will vary slightly for different types of errors. For example: in medium and in high myopia a good fitting lens rides slightly higher than in low myopia or in hyperopia. In with-the-rule astigmatism, the lower quadrant of the lens appears to stand off the cornea in that area, often creating a lozenge-shaped air bubble in the lower quadrant with the eyes in lateral secondary positions. At first, this type of patient feels less secure in making rapid visual excursions but seems to learn lid control very quickly. The lachrymal lens between the cornea and the contact lens in all cases has to possess a minus configuration so that there will be less clearance at the apex than

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near the limbus. It is advisable to have some clearance throughout the entire lens surface if that is possible. This result is accomplished by the selection of a contact lens approximately three-tenths of a millimeter flatter than the shallowest corneal curve present. A well-fitting corneal lens provides a lachrymal lens which shows the presence of many tiny mobile air bubbles under high magnification.

It is sometimes difficult to confirm corneal clearance, since the act of inspection often creates an artifact by causing excessive lachrymation as a result of the strong illumination used for inspection.

The lens should be loose enough to lag behind the eye in its excursions. It should not bind at the limbus and, in the average case, it should ride about a millimeter or less above the cornea. The overall diameter of the corneal lens should be less than the diameter of the cornea. The writer has found that the fluorescein picture of this lens, if viewed with an ordinary binocular loupe under daylight illumination, demonstrates apex contact in all cases. This may not be a true picture, however, since the lachrymal lens at the apex may be so thin that the fluorescein escapes notice at this point.

The undesirable sequelae of wearing these lenses to or beyond the tolerance limit vary in severity. Some of these sequelae are corneal haze, circumcorneal injection (especially in the upper quadrant), mild corneal abrasions (rare), conjunctival injections (both palpebral and bulbar), overactivity of the meibomian glands, and the development of stationary air bubbles. Real corneal haze, as is demonstrated by excessive wearing time in the case of the fluid type lens, is not caused by the Tuohy lens to the same degree. In fact, it is rare for corneal haze to develop even after 10 hours of steady wearing time if tolerance is built up slowly. Occasionally, we suspect corneal haze to be present only to find the condition has been caused by the presence of meibomian oils on the lens surfaces.

A condition of circumcorneal injection would, of course, indicate either that the fit is faulty or that the lenses are contra-indicated. It is not uncommon to find injections in the superior limbal quadrant after long periods of wearing time in even a well fitting lens. This condition is due to lid pressure on the edge of the lens, the curve of which is obviously steeper than the sclera.

It is the writer's belief that a well fitting lens should brush the cornea at the apex with no more pressure than that exerted by the lids. We believe that this produces a massage effect which presents one of the reasons why less inhibition sets in with the Tuohy lens. The writer has seen no real corneal abrasions which would take the fluorescein

stain, but we understand that in rare cases the corneas may be so affected, perhaps by ill-fitting lenses.

The conjunctival injection resulting from excessive wearing time is often associated with fatigue, but the condition is relieved within a very few minutes after removal of the lenses. The writer has observed one patient who dislodges his lenses by sending them up into his upper culdesacs when he feels fatigued. He leaves them up there for 10 minutes or so and then brings them back down again onto his corneas with renewed wearing ability.

Perhaps the most confusing sequel to excessive wearing time is the formation of stationary air bubbles which attach themselves to the corneal epithelium. This phenomenon is not common and is attributed to a corneal irregularity which creates a lake which is deeper than the rest of the lachrymal lens, from which the air bubbles find no outlet and are perhaps subjected to slightly more pressure. Upon removal of the lenses, the corneal epithelium presents a stippled appearance in the area of the bubbles which is relieved within a very short time.

If the results of other contact lens specialists confirm the writer's observations, it would seem that Tuohy has created a lens which surpasses the fluid type lens in many respects.

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ABSTRACTS

RETROLENTAL FIBROPLASIA. W. C. Owens and E. U. Owens. American Journal of Public Health. 40:405-408. April, 1950.

This paper reviews the earlier literature on this disease and gives the results of the author's observations and attempted therapy at The Johns Hopkins Hospital. Weekly examinations of the eyes of each premature infant, with a birth weight of 2,000 gm. or less, admitted to this hospital were made. The findings were:

1. The disease occurs in about 15 per cent of premature infants with birth weights of 1,360 gm. (3 lbs.) or less.
2. The disease is not present at birth; the first changes occur when the baby is about one month old. The complete retrolental membrane is usually formed by the time the baby is four months old. Both eyes are usually affected, but may not be to the same degree.
3. The earliest changes are seen in the retinal blood vessels: the veins become greatly dilated while the arteries become unusually tortuous. Subsequent changes are retinal edema, proliferative retinitis, retinal detachment and formation of the membrane.

The authors conclude that it is essentially a post-natal retinal disease of probably metabolic origin. Very encouraging results were obtained with Vitamin E. About 650 cases per year are to be expected in this country.

RICHARD FENTON

THE EFFECT OF VARIOUS ILLUMINANTS ON VISION*

WITH FOUR CASE REPORTS

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When neon signs first appeared on our city streets, I was asked by patients why some of the glowing letters appeared clean cut while tubes of other colors in the same sign were blurred. Of course the phenomenon of different focal lengths for different colors when passing through the same lens is familiar to all of us, although some have not stopped to think how striking this effect may become through some of the stronger ophthalmic lenses in daily use.

I became interested in studying the effect of various colors on visual acuity when both object and background were colored, and searched through the literature to review the studies that had been made.

In 1704, Sir Isaac Newton made the following comment: "It is to be noted that the most luminous of the prismatic colours are the yellow and orange. These affect the senses more strongly than all the rest together; and next to these in strength are the red and green. The blue compared to these is a faint and dark colour, and the indigo and violet are much darker and fainter, so that these compared with the stronger colours are little to be regarded."

These observations by Newton have not been changed although more than two centuries have passed. Whether Newton used prismatic colours for backgrounds in examining vision or whether he just observed their apparent "brightness" as compared one to the other is not definitely known.

More than a century had passed from the time of Newton's observations when Fraunhofer in 1817 published his work on the measurements of the brightness of the different colors of the spectrum.

In 1869 Vierordt published his observations on the "strengths of coloured lights" of the spectrum. His curve and Fraunhofer's curve are similar except toward the violet end. I quote another authority as follows:

> If there is a definite relationship in retinal stimulation from the various colours, it will depend upon many factors: intensity of each color, distance from object, size

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of pupil, intelligence and education of the individual, familiarity of the subject, general health, and such factors as time of day, fatigue, photopic or scotopic habituation prior to examination, the phenomena of color recognition and other factors which we have as yet not learned to consider.

As far as my senses are concerned I have the impression that in heterochromic luminosity equations it is not a question of the comparison of one magnitude but of the combination of two, brightness and colour-glow (Farbengluth), for which I do not know how to form any simple sum, and which, too, I cannot further define in scientific terms.

This candid expression by Helmholtz leaves no doubt as to his opinion of the difficulty of comparing luminosities of different colours.

We, realizing what an important part color is playing today, desired to compare the acuteness of vision when different colors were used as backgrounds. Research was started at the Pennsylvania State College of Optometry, using the senior class as subjects. The project consisted of experiments to determine under controlled conditions the actual figures for acuity on the familiar scale. To make the results as practical as possible, we used for our colors the usual neon sign colors as produced by electrical discharge through gases sold to the trades as neon, argon, and helium. More than 22,000 readings were taken.

The test room was so arranged that the various light sources used in turn each illuminated the charts to a photoronocally measured intensity of seven and a half foot-candles.

Many authors have defined the terms "visual acuity" and "visual efficiency" in such manner that no doubt is left as to their meaning. The research done and quoted was based upon Snellen test types and recorded as visual acuity. These letters subtend an angle of five minutes at various specified distances. The width and height of each letter being divided so as to form 25 square minutes of arc, making the minimum separable subtend an angle of one minute. This method is the one commonly used for notations of visual acuity.

Many factors were taken into consideration at the outset of this study:

(a) All subjects were rendered scotopic before any acuity was noted.
(b) The subjects were all examined at the same time of day.
(c) Ametropic corrections were worn.
(d) Charts used were based on Snellen's test types.
(e) Black letters were used on the following backgrounds: white, red, orange, yellow, green, blue and indigo. One chart was used with white letters on a black background.
(f) The illumination on each chart was 7.5 f.c. The following illuminants were used: incandescent lamps; neon, argon, and helium discharge lamps.

(g) The acuity for each chart was noted for the one illuminant exclusively, and the entire procedure repeated for each new illuminant.

(h) The acuities were taken at 20 feet.

(i) Sixty-six subjects were examined.

SUMMARY OF RESULTS

BACKGROUND	LETTERS	ILLUMINATION	V. A., O. U
White	Black	Incandescent	20/15
White	Black	Neon	20/17
White	Black	Argon	20/18
White	Black	Helium	20/18
Red	Black	Incandescent	20/19
Red	Black	Neon	20/19
Red	Black	Argon	20/47
Red	Black	Helium	20/24
Orange	Black	Incandescent	20/19
Orange	Black	Neon	20/19
Orange	Black	Argon	20/24
Orange	Black	Helium	20/19
Yellow	Black	Incandescent	20/14
Yellow	Black	Neon	20/19
Yellow	Black	Argon	20/19
Yellow	Black	Helium	20/14
Green	Black	Incandescent	20/21
Green	Black	Neon	20/59
Green	Black	Argon	20/27
Green	Black	Helium	20/45
Blue	Black	Incandescent	20/23
Blue	Black	Neon	20/60
Blue	Black	Argon	20/28
Blue	Black	Helium	20/26
Indigo	Black	Incandescent	20/33
Indigo	Black	Neon	20/37
Indigo	Black	Argon	20/58
Indigo	Black	Helium	20/100
Black	White	Incandescent	20/17
Black	White	Neon	20/19
Black	White	Argon	20/19
Black	White	Helium	20/19

No matter how difficult may be the comparison of luminosities of different colored objects, the fact remains that the yellow and orange still afford the highest visual acuity when used as a contrast to black.

It is interesting to note that from Newton down to the present-day scientists, not one differed with Newton's original observations that the most luminous of the colors were yellow and orange.

Now that we have studied ways to approach maximum acuity, let us examine certain factors that I believe affect acuity unfavorably. As a practicing optometrist, I constantly meet men and woman having trouble with their eyes. It is a matter of record that a number of these patients were working under fluorescent illumination. From this par-

ticular group, the following discomfitures were noted: lachrymation, conjunctivitis, marked fatigue after a short period of work, headaches and ocular pains.

According to the NEW YORK TIMES fluorescent lighting, highly acclaimed by many as the "latest word" in illumination, is sometimes unsuccessful when it comes to providing a satisfactory light for the human eyes, Dr. Gertrude Rand, specialist in optics, said in a talk before the New York Residence Lighting Forum of the Illuminating Engineering Society.

Rand, who was engaged in research work in optics at Johns Hopkins University for many years and now is associated with the Institute of Ophthalmology, Presbyterian Hospital, New York City, said that eye troubles of "patient after patient" were being traced to work under fluorescent systems in which the lights were "too bright to have unshielded." Experiments have shown that high brilliancy produces more fatigue in eye muscles than does any other type of strain, she claimed. Rand is only one of many scientists who have recognized the ill effects of unshaded fluorescent lighting.

Although the symptoms noted in a previous paragraph are common to individuals working under improper incandescent lamps, they are generally relieved when proper treatment is instituted. Patients working under fluorescent light may find some relief when a filter is prescribed which gives the effect of adding the lost color to the fluorescent spectrum by reducing all others. This does not relieve the stroboscopic effect, however.

We who do eye work do not as a rule desire to prescribe absorptive lenses for constant use. However, when there is no other alternative, we must resort to them.

The following cases are from my records:

Miss W., age 29 years; waitress, working under fluorescent light; wearing glasses. Symptoms: eyes burn and become quite inflamed; eyes tear; vision at times confused. The refractive error was corrected. The patient had no relief from any symptoms. Treatment was instituted but still no report of relief. We resorted to the same prescription in combination with a filter. The patient was relieved of all symptoms except a confusion of vision occasionally. The patient was requested to wear white lenses when not under fluorescent light. She suffers from no visual confusion when not under fluorescent light.

Mr. D., age 30 years, wearing glasses; this patient is an accountant working under fluorescent light. Symptoms: confusion of vision at times; eyes fatigue about two o'clock in the afternoon and then begin to tear and burn. There was no change in refraction so the same prescription was used but a filter was added. All ocular symptoms cleared up except the confusion of vision. He was ordered to wear white lenses when not under fluorescent light.

Miss S., age 38 years, who had been wearing a filter for some time, necessary for another condition, accepted employment in a dry goods establishment. After a month or so of employment the proprietor changed his lighting to the fluorescent type. When the complaints of tearing, fatigue, ocular pains and confusion of vision were

voiced by the other employees. Miss S. still carried on with no ocular complaints other than confusion of vision, although she has a poor pair of eyes from a standpoint of pathology.

Mrs. R., age 40 years, wearing glasses and doing fine assembly work, complained of headaches, fatigue after a short period of work, tearing, inflamed eyes and stroboscopic effect. The lenses she wore were perfect except that a filter was added. The patient was relieved of all symptoms except the stroboscopic effect. She was advised to seek another position where fluorescent lights were not in use. She did this and is now symptom-free ocularly.

My attention was called to the effect of synchronization between stroboscopic effect of a fluorescent tube and the turning of a lathe. The machinist thought that the chuck was not revolving and his attempt to take hold of this part resulted in two fingers being severely damaged.

Another case reported that the motion of needles on a knitting machine in synchronization with a fluorescent tube caused the individual to have it appear as though dots were running off into space.

The above mentioned cases are only a few from among a large number in my records. This same type and others are being met by many practitioners and engineers throughout this country. Evidence proves that something more must be done about poorly designed fluorescent before we become a filter-wearing nation, which is *not* the answer to our problem.

In this respect the writer feels that to treat the end result rather than the cause certainly is not practicing in a true humane manner. Can we not as a professional society concerned with eye health take a stand in favor of all possible improvements in illuminants? Since the spectral distribution of the fluorescent lamp with the mercury lines super-imposed over the fluorescent spectra is strongly suspected of being one of the important contributing causes, due either to disturbed visual acuity or in some other way, for the problems I have cited, I suggest that fluorescent equipment be made commercially available with gasses or phosphore filling in needed colors, or with color screens or tinted reflectors to promote the same results. Equally important is the reduction of high frequency flicker. The manufacturer must work toward use of ballast equipment that will give three or more phase relations to smooth out the flow of light, or secure a similar result by feeding units from polyphase circuits. Any help from phosphores with slower action is clear gain. It is astonishing how many stroboscopic installations are still being sold in spite of all good engineering advice. And by all means let us insist upon screening from direct view all fluorescent lamps. The fluorescent tube is a light source of great potentialities. Let us give it every possible chance.

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APPARENT ACCOMMODATION IN APHAKIA*

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Aphakics have been reported who, despite the loss of the crystalline lens, possess some means of discriminating small detail, both at near and far while using the same optical correction. Mason,[1] in demonstrating the untenability of one theory, that a bead of vitreous may be pushed forward during contraction of the ciliary, explains the phenomenon on the basis of "the *caustic* surface in the refracted rays which focus near the retina." He concludes that, "Although knowledge is scarce respecting the causation of this phenomenon it is, nevertheless, a representation of a feature of the eye's performance which is commonly observed upon the intact eye namely, the ability of the eye to discriminate small detail at the reading position while, in fact, being focused for vastly greater distances." An additional case is here reported, with the methods used in its investigation.

The case, a patient of Dr. Bettman, will be reported by him in detail elsewhere.[2] For the present discussion it is sufficient to state that the patient, aphakic for several years, could read with his distance correction (as determined by skiascopy) both 20/20 on the Snellen chart and Jaeger #1 at 33 cm.

A characteristic of accommodation which is consequent upon ciliary action is the elapsing of some time in changing the refractive power of the lens and, hence, of the eye when the target distance is changed; two objects, one at infinity and the other at the customary reading plane, cannot be seen clearly simultaneously, but rather alternately with a lapse of time between fixations. In the present case it was desired to learn whether such a time interval existed.

In the first experiment the patient stood 20 feet away from a well illuminated Snellen chart and held a square of wire screen, such as is used in window screens, at a distance of 25 cm. Looking through the

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[1]Mason, Frederick L., Principles of Optometry, Part I, p. 195, Second Edition. A. Carlisle & Co., Upham & Rutledge, Inc., San Francisco, Calif. 1940.

[2]The author is grateful to Dr. Jerome Bettman for the opportunity of observing this case. The detailed study by Dr. Bettman including a description of the surgery, case history, other tests performed, reports of the patient and other pertinent information will appear at a later date in the ophthalmological press.

screen, the patient was able to read the 20/20 line on the chart. When asked if the wire of the screen was clearly seen, the patient reported that it was, and also that the screen did not become any clearer when he consciously fixated it, nor did the Snellen letters blur when the screen was fixated. Thus, both the near and distant object were seen at maximum clarity simultaneously. Each of the (non-aphakic) experimenters[3] attempted the same task and could see either the chart or the mesh at will, but could not see both clearly at the same time. Clearing the letters on the chart involved blurring the screen, and *vice versa*.

The second experiment, based upon the same principles as the first, was performed in a dark room. The patient was seated 33 cm. from a large plane mirror. A letter "C" 2 mm. in diameter had been pasted on the front of the mirror slightly to one side of the eye being tested. Another, larger letter "C" was projected on a screen 3 meters behind the head of the subject: this was of such size and so located that the smaller "C" pasted on the mirror was seen within the reflected image, and concentric with it. The larger "C" required 0.30 D. of accommodation, while the smaller one required approximately 3.00 D. With the room illuminated, both letters could be seen: with the room lights off only the larger, more distant, projected letter could be seen: with the room lights on and the projector lights off the smaller object only was seen.[4]

The patient was seated before the apparatus in the darkened room and was asked to keep the larger "C" clear. The room light was turned on and the subject was asked whether he could see anything within the larger "C." He reported that he saw the smaller "C." He was asked if it had been seen clearly instantly and reported that it had. He was able to see both of the letters clearly and simultaneously. Looking at one did not cause the other to blur, nor was it possible for him to blur one or the other. The experiment was repeated upon the non-aphakic experimenters, each of whom required a definite time lapse in shifting fixation from one letter to the other. For these observers the clearing of one of the letters involved blurring the other, and none of the observers

[3]In addition to the author, the other experimenters were Dr. Jerome Bettman of the department of ophthalmology, Dr. Arthur J. Jampolsky of the same department, and Professor Frank W. Weymouth of the physiology department, all of the School of Medicine of Stanford University.

[4]It might be mentioned in passing that the mirror device mentioned here offers possibilities for a cheap and simple device for home training of accommodation. A mirror with letters pasted on it and an object some distance behind the patient can be used to administer "accommodative rock," the patient having to clear first one and then the other of the objects. The distances involved would, of course, determine the amount of accommodation required during the training process.

could see both letters clearly simultaneously.

These observations are not offered as an explanation of the complex phenomenon of apparent accommodation in aphakia. However, they do demonstrate one major difference between such cases and those possessing accommodation consequent upon a ciliary body and crystalline lens. In the latter cases, a near and distant object cannot be seen clearly and simultaneously; in the aphakic examined this was possible. In the normal subject a certain amount of time is required to clear first one and then the other of two objects at different distances, while in the aphakic this is not the case, no time lapse being demonstrable.

ABSTRACTS

VOLUNTARY HEALTH INSURANCE ON THE NATIONAL SCENE. THE UNITED MINE WORKERS HEALTH PROGRAM. Warren F. Draper. American Journal of Public Health. 40:595-601. May, 1950.

This paper outlines the U. M. W. health program. With respect to "optical" services it states: "Dental and optical services are limited for the time being to persons whom the physician believes require these services in the treatment of a specific illness."

RICHARD FENTON

IMPROVING THE QUALITY OF MEDICAL CARE. GROUP MEDICAL PRACTICE. Dean A. Clark. American Journal of Public Health 39:321-328. March, 1949.

The author's thesis is that group medical practice, in combination with good personnel training, regional planning and sound administration is an excellent method of improving the quality of medical care because of the many professional and economic incentives it affords. Fee splitting and rebates are evils which group practice can eliminate, according to the author. Optometrists will find the following paragraph of interest: "But it is not the act of splitting a fee that makes this practice an evil and an impediment to a high quality of medical care. It is, rather, the fact that the split is unknown to the patient and unregulated in amount and volume. Thus, the patient does not know, when he buys a pair of eye glasses from an optician, for example, that part of what he pays may go back to the doctor who referred him to that optician. The same is true, of course, for x-rays, surgical procedures, and so on. The result of hidden fee-splitting is that if a sizeable split is in the offing the physician may be tempted to refer patients more frequently than is medically necessary and to send his cases to the doctor or laboratory or optician who gives the biggest kickback rather than the one professionally most competent to handle the case. The magnitude of the practice of fee-splitting may perhaps be gauged by the fact that more than 4,000 eye specialists—about one-half of those in the United States—were involved when the U. S. Department of Justice sought to stamp out rebates in the optical industry."

RICHARD FENTON

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ACADEMY TO HOLD ANNUAL MEETING IN CHICAGO

Chicago is again the popular convention city for the coming annual meeting of the American Academy of Optometry. This will be the 29th annual meeting of the Academy. This four-day session, scheduled for December 16, 17, 18 and 19, is now taking shape and Academy members can expect and will get the usual high quota of outstanding technical papers presented by the top specialists in vision.

The 1950 meeting place of the Academy is one of the cross-roads of America. Member optometrists and educators from the Canadian provinces and from the states find Chicago easily accessible by either highway, rail or plane. This will be the eighth annual Academy meeting in Chicago, the others being held during 1928, 1932, 1936, 1940, 1941, 1944 and 1947. No other city fulfills the requirements for

convention goers quite as well as Chicago, which no doubt accounts for the many Academy sessions held in its great convention hotels. This year, the *The Drake Hotel* is headquarters for this international optometric scientific conclave.

As usual, the Academy sessions will start at 9:00 a.m. Saturday and run through the following Tuesday afternoon. A short business session will be held Monday afternoon, and the usual round table banquet of the Academy will get under way at 7:00 p.m. Monday.

The remainder of the four day and evening period is to be devoted to clinical and technical section meetings and to the presentation of original papers dealing with all phases of the work of optometrists and related subjects in the general field of vision. During the two-hour morning section meetings each day, clinical demonstrations having to do with orthoptic training, aniseikonic corrections and contact lens fitting will give the attending specialists an up-to-the-minute review of the progress made in these fields since the last meeting of the Academy.

The papers and program committee and the section chairmen are now arranging the schedule of papers and events. Members of the Academy still wishing to present clinical or scientific material should write at once to the chairman, Dr. Robert E. Bannon, 46 Lebanon Street, Hanover, New Hampshire, to enable proper program scheduling. The complete program will be announced in November.

Local arrangements for the convention will be in the hands of the Illinois chapter of the Academy. Our Illinois hosts are, as usual, expecting a large attendance of Academy members. Every Fellow of the Academy is expected to make a determined effort to be on hand for this annual meeting as these sessions are considered to be the outstanding educational treat offered each year to optometrists.

To recap—the dates are December 16, 17, 18 and 19. The city, Chicago. The place, the Drake Hotel. The event, the annual meeting of the American Academy of Optometry. This is a "must" for all Academy members.

CAREL C. KOCH

Obituary

ELMER E. HOTALING

On July 22, 1950, Elmer E. Hotaling died in New York City, after an illness of many months. He began his distinguished career as an optometrist, and, although he entered the fields of instrument

designing and editing he remained first and foremost an optometrist throughout his life.

Since 1914 he has been in practice in New York City, associated with E. LeRoy Ryer and during that period the names "Drs. Ryer and Hotaling" have come to symbolize the very best there was in scientific, ethical optometric practice.

Dr. Elmer E. Hotaling received his undergraduate education at the City College of New York and his graduate optometric training was taken at the Philadelphia College of Optometry where he received his degree in 1912.

His notable contribution to optometric science was made in the field of radiation. He conducted a number of studies having to do with the effect of infra-red radiation on the metabolism of the crystalline lens. These studies were presented to the American Academy of Optometry in 1933.

With his colleague, Dr. Ryer, much early work was done in developing the visual acuity chart used by the General Optical Company in their refracting room instrument for this purpose and many refinements were added to early ophthalmometers as the results of their studies.

Dr. Hotaling became a Fellow of the American Academy of Optometry in 1923 and served as a member of the Executive Council of the Academy in 1928, 1938, 1939 and 1940. He has also been active as a member of the editorial council of the Academy for many years.

He served as president of the New York Academy of Optometry, the Optometric Society of the City of New York, and the national optometric fraternity, Omega Epsilon Phi.

Dr. Hotaling, in addition to his Fellowship in the American Academy of Optometry and the New York Academy was also a member of the New York State Optometric Association and the American Optometric Association. In the latter organization he served with Dr. Ryer as an associate editor of the *Journal of the American Optometric Association*. He was an honorary member of a number of optometric state associations.

He was married to Madeleine Edwards who survives him. Dr. Hotaling's character was distinguished by an unswerving devotion to professional and scientific optometric practice and he was never willing to compromise with less than the best optometric science could offer.

CAREL C. KOCH

TRANSACTIONS OF THE AMERICAN ACADEMY OF OPTOMETRY

A department devoted to announcements, reports, appointments, organization data, news, professional problems and ideals, as these relate to the Academy.

NEW MEMBERS OF THE ACADEMY

The following optometrists and educators received their final approval for membership during the second quarter of 1950. The Academy welcomes these new members.

Dr. Dorothy A. Bergin, Los Angeles College of Optometry, Los Angeles, California.

Dr. Harold S. Bobb, 228 Empire Building, Denver, Colorado.

Dr. Daniel D'Arcy, Los Angeles College of Optometry, Los Angeles, California.

Dr. Harry A. Jankiewicz, Los Angeles College of Optometry, Los Angeles, California.

Dr. David D. Michaels, Chicago College of Optometry, Chicago, Illinois.

Dr. G. William Seabold, 1025 Fidelity Building, Baltimore, Maryland.

CURRENT COMMENTS

Virginia Huck
Editorial Assistant

Optometrists will confer a favor by sending news items for general interest for this department; such as relate to new instruments, clinical techniques, education, visual health and optometric legislation and organization.

CHO TSO, THE GOD OF OPTICIANS

A true tale, but one with a quaintly Alice-in-Wonderland touch has just come to the office. Cho Tso turns up as God of the Opticians—Mao the Rabbit is a −10.00 D. concave spherical lens—the Tortoise is used for frames while the Tea Crystal gives sight to all.

To put first things first, however, I must tell you that in 1912, Otto D. Rasmussen became associated with an Ohio physician who established an eye clinic in China. Rasmussen practiced optometry in that fantastic land until driven from the country by the Japs during World War II. The now Chinese exile, Rasmussen, is in England where he has written a monograph dealing with his years of practice in China, *Chinese Eyesight and Spectacles.*

His book is informally written, in a delightful style. It contains a wealth of love for his former patients and fellow citizens. He finds them mixing facts and superstitions in a charming manner and from his case box he brings us a number of whimsical studies like that of Tommy Loo.

As a little boy, Tommy Loo was dragged to Rasmussen's rooms, hiding behind his mother's skirts. Here Rasmussen listened to a chapter out of a Chinese bad boy's diary. He was 10, born of parents who had grown up in foreign settlements, and was at the bottom of the class. When not caned for playing truant, he carried home notes from his teacher inviting his parents to use the rod. Every month his marks were zeros. The school wanted to expel him several times, and on each occasion Tommy got a spanking. The Chinese do not as a rule believe in corporal punishment for children, but Tommy was an exception.

His teachers complained that the boy pretended not to see. He refused to look at a book or blackboard for more than a few seconds, and then did so with a sidewise glance. Mrs. Loo took him to a foreign physician, on a day when the latter happened to be sober (there are such derelicts in Chinese ports). The doctor said Tommy was a malingerer, whereupon Tommy got another spanking. Subsequently, a native optician said the boy had a case of nerves for which no glasses would do.

Tommy cowered in Rasmussen's refractive chair in tears, shivering and dumb. He knew what to expect after someone examined his eyes. He did not get it, though, for he had a simple case of muscle spasm. Tommy was right in three months, and got good marks in school. For some months afterwards Tommy came to Rasmussen's office every Saturday morning with a bunch of flowers, which Rasmussen thinks was not so much Tommy's idea as his mother's.

But to get back to the book. Cho Tso is the Chinese God of Opticians. He lives in the sacred mountains of China where the clear cold streams polish the rock crystal lenses—where the tortoise supply their shells for spectacle frames. This bit of whimsey—along with the widely believed medicinal powers of rock crystal "tea" colored lenses adds charm to the many technical and historical facts presented by the author. Sixty-five per cent of the spectacle wearing public use concave lenses. The author straightens out some of the historical folk-lore about the early use of spectacles by Chinese. It is true, he claims, that spectacles were used in China for hundreds of years before they turned up on the noses of people in Europe, but he adds, in China, they were used for mystical and medicinal purposes as well as to prevent injury

from glare. Many of the early Chinese spectacles were glazed with non-focus plano brown amber color lenses made of tea crystal.

Rasmussen finds that convex and concave lenses were not in evidence in China until the 13th century when the correction of refractive problems by glasses seemed to start. As in Europe, at that time, this was done largely through the trial and error method.

Because the early opticians had no scale of values for lens powers, the Chinese created one in which lens powers were given names. Concave spherical lenses of approximately 20.D were called Tze or Rat. The —16.D. lens, Ch'ou or Ox. —14.D Ying or Tiger. —10.D. Mao or Rabbit. —8.D Chen or Dragon. —6.D. Sze or Snake. —4.D. Wu or Horse. —3.D. Wei or Sheep. —2.D. Shen or Monkey. 1.50.D. Yu or Cock. —1.D. Hsu or Dog. —0.50.D. Hai or Pig. On the convex side only four powers were made. These were +1.D, +2.D, +3.D, and +4.D. These were used only for non-myopic presbyopic cases and were called 40 year lenses, 50 year lenses, 60 year lenses and 70 year lenses. It was all very simple and no one had to fool around with prisms or cylinders. But it was all very serious, too, as there were many persons with visual problems, just as there are today.

New methods of refracting and spectacle making came slowly, and in many of the remote parts of China today the optician's art is practiced much as it was 500 years ago.

Rasmussen, with his life long Chinese experience, gives a vivid word picture of both early and modern optometry in China. This is a well written historical monograph. Optometrists of the States and Canada may secure a copy by sending $2 to the author, at his home, 129 High Street, Tobridge, Kent, England. This delightful little book will entertain you and find a place of welcome on the shelves of your technical library.

GADGETS FOR THE BLIND

Stimulating summer reading is Franklin S. Cooper's "Guidance Devices for the Blind," in *Physics Today* for June. In the article, Cooper discusses the problem of independent travel for the blind, and the reasons for failure of electronic devices to aid these handicapped persons. Typical hazards to independent travel are reviewed briefly: Street crossings, edges of platforms, mailboxes, open manholes, etc., and the efforts of scientists to perfect mechanical devices which aid in avoiding such obstacles. Most guidance gadgets work in theory, but not in practice, Cooper points out. Optical and supersonic devices have been made which will warn of obstacles, but the warnings require special interpretation difficult to teach the blind in any practical length of

time. A device that requires an engineering degree to operate is obviously useless.

The problem is as much psychological as mechanical. The main problems center around questions like these: How should information be organized and presented in order that it may be most readily perceived? How long a period of learning will be required for the effective use of a device, assuming that the information it provides is adequate and well organized?

A guidance device is of little use to a blind person until he has completely mastered it and the signals can be interpreted automatically and unconsciously. To date, none of the instruments are practical from this standpoint.

Cooper believes the prospects are reasonably bright for perfecting a device that *can* be mastered. Until then, the blind must continue to rely on dogs, canes and obstacle sense.

INTERNATIONAL OPTICAL CONGRESS IN LONDON

July, 1951, will be an excellent time for optometrists to visit London, promises the British magazine, *Optician*. During that month, the "world's largest, most diverse exhibition of ophthalmic optical products" will take place. An International Optical Congress is being planned for the same month, and another attraction for overseas visitors at this time is the Festival of Britain. In view of these events, Britishers have extended an early invitation to travellers to "Come to Britain in July, 1951." Sounds like a very fine idea!

PROGRESS

The A. O. A. Congress held in Minneapolis is history now, history we can be proud of—and now optometrists the country over are looking ahead and planning new meetings. But even though the Congress has been over two months, we still look back and remember some of our thoughts while attending meetings, chatting with delegates, and listening to lectures.

One couldn't help thinking, while at the Congress, about the breathtaking progress the profession of optometry has made in the last decade.

Achievements on all "fronts" make an impressive record today . . . new recognition by the armed forces; long strides toward the goal of complete professionalism; stronger liaison with allied sciences; scientific progress in industrial vision problems, aniseikonia, contact lenses, refractive problems; better public relations.

It must be remembered, however, that while the progress has been

rapid, it has not been easily gained. The lives of many men have been devoted to moving the profession ahead. And only by a great deal more of the same kind of work and devotion, will we be able to think in the future, as we did during the Congress, "What breathtaking progress optometry has made!"

NEW JERSEY GROUP AIDS NEW LICENSEES

A most practical and realistic type of conference for optometrists was sponsored in July by the New Jersey Optometric Association. Practitioners just getting started, and those who have been in practice only a few years, were called together to discuss the problems encountered in building a practice. In addition to general discussion and exchange of experiences, nine men offered specific suggestions for improving a practice:

Dr. E. C. Nurock covered the subject of professionalism; Dr. Benjamin Sobel, the need for an association membership; Dr. Phillip Jackman, self improvement; Dr. Martin Snook, and Dr. A. F. Fischer, community relations; Dr. Paul Ellin, patient management and office procedure; Dr. A. R. Neale, Jr., fees; Dr. J. J. Brown, relationship with the state board, and Dr. Harold Bookstaber, office location.

The New Jersey association is to be complimented on this type of aid to new practitioners, and those states not already carrying on similar conferences might study their methods. Group consultations on this order become more and more important as the number of graduates going into practice increases, and it is to the advantage of all when the new licensees get off to a good start.

NEWS BRIEFS

Dr. Lewis H. Kraskin, Washington, D. C., will soon be able to celebrate 25 years continuous service with the District of Columbia Board of Optometry. His first appointment was in 1926; his latest reappointment for another term came last month. Dr. Kraskin is past president of the board and currently its secretary-treasurer. . . . Chicago College of Optometry has inaugurated a series of all-school assemblies planned to keep students informed on current optometric problems. Each month, a nationally known optometric speaker will bring the students up to date on trends, research activities and problems of the practicing optometrist. . . . New officers of the Northern Illinois College of Optometry Alumni Association, elected at the A. O. A. Congress, are: Dr. Phillip Jackman, Hackensack, New Jersey, president; Dr. Marilyn Brenne, Manitowoc, Wisconsin, vice president; Dr. John Kennedy, St. Paul, Minnesota, secretary-treasurer.